Finance Research Letters xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Finance Research Letters

journal homepage: www.elsevier.com/locate/frl

A bibliometric analysis on green finance: Current status, development, and future directions

Dayong Zhang[a,*], Zhiwei Zhang[a], Shunsuke Managi[b]

[a] Research Institute of Economics and Management, Southwestern University of Finance and Economics, Chengdu 611130, China
[b] Urban Institute & School of Engineering, Kyushu University, Fukuoka, Japan

ARTICLE INFO

Keywords:
Bibliometric analysis
Climate change
Green finance

ABSTRACT

With growing global actions toward climate changes, green finance receives large attention in recent literature. It is though conceptually unclear, with no consensus achieved on its definition among researchers. This paper provides a brief review of the recent advances in green finance research. It uses a bibliometric analysis approach to summarize the status quo and development trends of green finance. We assist establishing a solid conceptual base and guidance to future research directions.

1. Introduction

Climate change and sustainability have drawn broad attention internationally. World leaders have found a general consensus on this issue, as stated in the 2015 Paris Agreement within the United Nations Framework Convention on Climate Change (UNFCCC). While member countries have agreed to work cooperatively to mitigate the severe problem of greenhouse gas (GHG) emissions, one of the major challenges is the financing mitigation and adaptation action to climate change and sustainability. Significant amount of investment is needed for solving the problem. Maintaining the 2 °C temperature threshold of the Paris Agreement requires $53 trillion in energy-related investments by 2035 (International Energy Agency (IEA), 2014).

Ji and Zhang (2019) document that financial development is a critical determinant for the further progress of China's renewable energy sector. In 2010, the Green Climate Fund (GCF) was established by 194 countries, aiming to provide financial support to developing countries to mitigate GHG emissions and adapt to climate change. Since then, the term "green finance" has frequently appeared in reports of international organizations (see for example, IFC, 2017) and national governments. Relevant discussions have also attracted enormous attention from academics. Green finance *per se*, however, remains vaguely defined and is often mixed with climate finance.

It is often hard to distinguish between green finance and climate finance. According to IFC (2017), green finance is defined as "*financing of investments that provide environmental benefits*", whereas the latter is proposed and defined by UNFCCC as "*local, national or transnational financing-drawn from public, private and alternative sources of financing-that seeks to support mitigation and adaption actions that will address climate change*". Though subtly different in definitions, at the heart of both terms is the financing tools for coping with climate change and others for sustainability.[1]

* Corresponding author.
E-mail address: dzhang@swufe.edu.cn (D. Zhang).

[1] We thank an anonymous referee for pointing out the issue of which term is a better choice between "green finance" and "climate finance". Green finance (as in IFC, 2017) will be used to emphasize global concerns on environmental issues but we do want to clarify that this term is broadly defined and thus indicating no differences to climate finance.

https://doi.org/10.1016/j.frl.2019.02.003
Received 22 January 2019; Received in revised form 6 February 2019; Accepted 19 February 2019
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Please cite this article as: Dayong Zhang, Zhiwei Zhang and Shunsuke Managi, Finance Research Letters, https://doi.org/10.1016/j.frl.2019.02.003

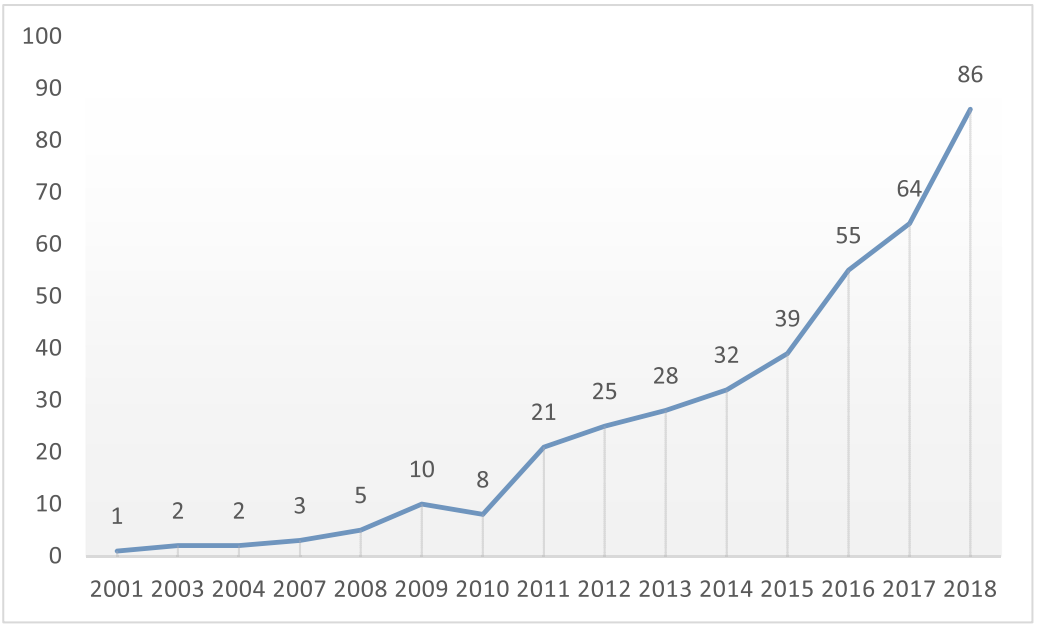

Fig. 1. Number of relevant publications.

Green finance clearly has paramount policy importance, reflected by the intensive discussions among international organizations and national governments since its emergence. It has also led to increasing interest among academic researchers. Zhang (2018), for example, emphasizes the importance of carbon finance within the general framework of green finance.

This paper starts from summarizing recent literature, aiming to first draw a big picture of relevant academic research. By learning from the current status, we hope to form a proper understanding of the conceptual issues, and more importantly, to identify development trends and provide useful guidance on future research directions in this important and developing subject.

2. Methodology and basic setups

The method used in this paper is a bibliometric analysis approach. It was first used by Pritchard (1969) and has gained wide popularity to aid quantitative analysis in understanding the literature. We use CiteSpace, a software developed by Chen (2006), to show visualizing patterns of the previous studies on green finance. Given the fact that a clear conceptual definition of green finance is lacking, we concentrate on three keywords search, namely, green finance, climate finance and carbon finance. We also include a number of keywords with small variations to increase the coverage of relevant literature, which are green financing, climate financing, carbon financing, green investment, and green bond.

For retaining the general information and ease of search, we impose several restrictions on identifying relevant researches. First, all candidate papers should be in the Web of Science core collection. Second, papers should be *Articles* indexed in one of the following indices: Science citation index-expanded (SCIE), Social science citation index (SSCI), Arts & Humanities citation index (A&HCI), and Emerging source citation index (ESCI). Effective samples cover the range from 2001 to 2018. Third, we manually go through all titles and abstracts to exclude irrelevant articles.

In total, 381 papers have been included in our sample. The number of papers published in each year is plotted in Fig. 1. A clear upward trend of publications can be spotted during the sample period. Noticeably, as opposed to the slow and steady growth trend before 2015, the number of relevant publications has increased sharply since 2015, which implies substantially increased interests from academics on green finance since the 2015 Paris Agreement.

3. Key results

Our bibliometric analysis will focus on four main areas and aim to answer the following questions: Which journals are these paper published? Where are the authors from (countries of origin)? What are the key interests (keywords analysis) of these studies? How are these paper cited in the literature?

Table 1
Journal distributions (main journals with publications over 4).

Journals	Number of papers	Journals	Number of papers
Climate policy	40	Mitigation and adaptation strategies for global change	6
Energy policy	16	Nature climate change	6
International Environmental Agreements-politics law and economics	13	World development	6
Ecological economics	12	Chinese journal of population resources and environment	5
Journal of cleaner production	12	PLOS One	5
Sustainability	9	Climate change	4
Environmental science & policy	8	Environmental & resource economics	4
Climate and development	7	Global environmental politics	4
Energy for sustainable development	7	International Journal of climate change strategies and management	4
Environmental research letters	7	Land use policy	4
Energy economics	6	Marine policy	4
Global environmental change-human and policy dimensions	6		

3.1. Journal distribution

Table 1 reports a list of journals according to their numbers of publications (of more than four relevant papers per journal) in our sample. Clearly, although finance is defined as a key element of green finance, the main journals publishing related works turn out to be those who concentrate on environmental and climate change. Not even one finance journal made to the list. In fact, by examining the list of papers published in finance journals, we did find some relevant ones, namely, one from Journal of Financial and Quantitative Analysis (Heinkel et al., 2001), two from International Review of Financial Analysis (Bredin et al., 2014; Turner, 2012), two from Emerging Market Finance and Trade (He and Liu, 2018; Celik and Binatli, 2018), and one from Finance Research Letters (Febi et al., 2018). Although the first paper in this collection is from a top finance journal, evidence here confirms what Diaz-Rainey et al. (2017) conclude, that the main stream finance journals are generally silent on the climate change issue.

Three key economics journals appearing in this list are Ecological Economics, Energy Economics and Environmental & Resource Economics, which are all field journals of environmental and resource economics. It is not hard to notice that green finance is yet to become the interest of mainstream economics or finance journals, despite its widely acknowledged importance and an urgent need of full-fledged policy and regulatory tools. Much remains to be done to bring this fast developing topic into the spotlight of mainstream economic and finance research, and to fill the wide gap existing in extant literature.

Two reasons exist to support our claims here. First, the amount of investment in green/climate projects have increased substantially and maintained a strong growth momentum in the recent years. For example, global green bond issuance had a historical record of 155.5 billion US dollars in 2017,[2] creating high demand for academic research in this area; Second, more people are interested in this area with increasing research outputs by a broader categories of academic researchers. Although it is a bit too early to see more publications now, a number of events associated with main stream finance journals in the last couple of years will surely link to relevant outputs (e.g. 2018 RFS Climate Finance Initiative in London[3]). Lacking of relevant research also means potentially high impact with ground-breaking research in this area. Overall, we are very positive to make the claim that an opportunity exists.

3.2. Authors' country of origin

It is also worth exploring where the keenness on green finance research mainly comes from. We look at this issue by linking it to the authors' countries of origin. Fig. 2 summarizes the information of country of origin of the authors. It depicts a clear picture showing that the main contributors to the recent fast progress of this field are mainly from the US, Europe and a few other developed countries. It is not surprising to see the dominance of US-based researchers in this field, as the World Bank, UN and many other most influential international organizations have their headquarters based in the US, which can much facilitate and encourage relevant research. For years, Europe has been the most enthusiastic promoter of global cooperation on climate change. Its world's largest carbon trading market (EU ETS) with a long history has attracted substantial attentions from academic researchers on green energy issues. The color in the figure also demonstrates time dimension. The lighter the color is, the earlier the work appears. It is observed that this subject is piloted and led by researchers from the US and England, while the majority of studies from other regions follow up and appear later.

Among all visible contributors' origins in the graph, China and India are the only two emerging economies. Considering the sizes of these two countries and their shares of global GHG emissions, it is very important to have China and India actively participating in the debates. The unbalanced distribution between developed and developing countries of origin may also imply that developed countries remain dominating on green finance topics. In the international negotiations on climate agreements, developing countries

[2] https://www.reuters.com/article/greenbonds-issuance/global-green-bond-issuance-hit-record-155-5-billion-in-2017-data-idUSL8N1P5335
[3] http://rfssfs.org/rfs-climate-finance-initiative/

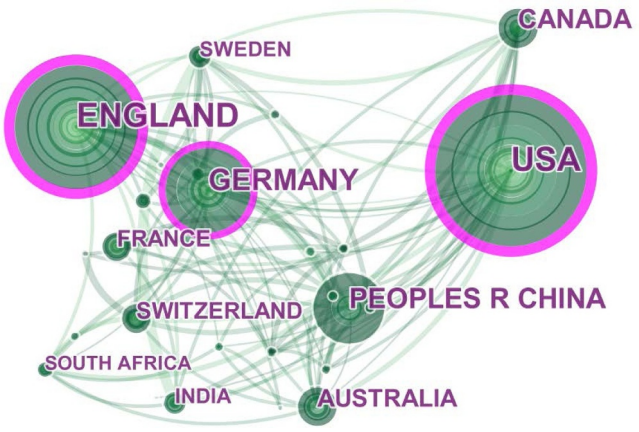

Fig. 2. Authors' country of origin.

Table 2
Top ten keywords.

Keywords	Frequency
Climate finance	71
Climate change	61
Policy	46
Adaptation	36
Mitigation	25
Country	23
Carbon finance	22
China	21
Emission	20
Management	19

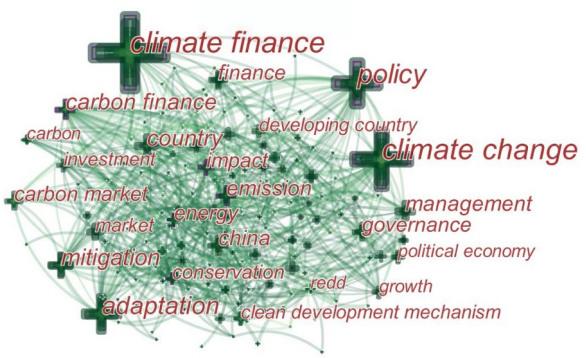

Fig. 3. Keyword analysis.

have been playing an increasingly important role. This is argued to be one of the main reasons that a universal agreement is difficult to reach (Costantini et al., 2016). Although developed countries are mainly the source of funding, without active cooperation from developing countries, it is hard to achieve efficient green financing or investment. Further investigations and understanding on developing economies and their status quo are very necessary. Of course, we have to acknowledge that academic research has been dominated by developed economies and author structure is unlikely to change much in a short period of time. Issues in developing countries however, should be one of the main future directions of research.

3.3. Keywords analysis

Table 2 lists the top ten keywords. *Climate Finance, Climate Change* and *Policy* are the top three main concerns in the literature. The objective of developing green finance is to cope with climate change and this is clearly a policy relevant question.

Fig. 3 provides a graphical illustration of keywords appearing in these articles. The graphical information combined with the

Table 3
Top cited articles.

Author	Journal (year of publication)	Cited count	Title
Heinkel et al.	Journal of Financial and Quantitative Analysis (2001)	183	The effect of green investment on corporate behavior
Ebeling and Yasue	Philosophical Transactions of the Royal Society B-Biological Sciences (2008)	125	Generating carbon finance through avoided deforestation and its potential to create climatic, conservation and human development benefits
Macreadie et al.	Marine Pollution Bulletin (2014)	68	Quantifying and modelling the carbon sequestration capacity of seagrass meadows - A critical assessment
Palm et al.	Proceedings of the National Academy of Sciences (2010)	68	Identifying potential synergies and trade-offs for meeting food security and climate change objectives in sub-Saharan Africa
Lewis	Energy Policy (2010)	60	The evolving role of carbon finance in promoting renewable energy development in China
Brodie et al.	Trends in Ecology & Evolution (2012)	55	Climate change and tropical biodiversity: a new focus
Stringer et al.	Environmental Science & Policy (2012)	54	Challenges and opportunities in linking carbon sequestration, livelihoods and ecosystem service provision in drylands
Jeuland and Pattanayak	PLOS One (2012)	51	Benefits and Costs of Improved Cookstoves: Assessing the Implications of Variability in Health, Forest and Climate Impacts
Ballestero et al.	European Journal of Operation Research (2012)	49	Socially Responsible Investment: A multicriteria approach to portfolio selection combining ethical and financial objectives
Peskett et al.	Environmental Science & Policy (2011)	46	Institutional approaches for carbon financing in the forest sector: learning lessons for REDD+ from forest carbon projects in Uganda

world top ten list reveals some interesting patterns. In addition to the core issues, a number of keywords are shown to have attracted much attention. For example, *Management* is ranked the 10th, which reflects the concerns on how green finance is managed by a state or in a market. Another relevant keyword (*Governance*) also visible in Fig. 3 is related to management, indicating that proper governing is an important concern to green finance. Researchers are also interested in *Impact*, or how much green finance may affect sustainability and development (*Growth*). *China* is the key player of green finance and thus is unsurprisingly an important research focus. *Market, Finance* and *Investment* fail to make to the top ten list, but they are clearly visible in Fig. 3, implying the needs to study green finance topics from finance aspects.

Keywords analysis conveys important information that can be used to clarify the conceptual points of green finance. It is obvious that green finance is related to climate change and should be policy driven. Issues of financing or investment on climate adaption are the key subject of interests. Green finance is not only relevant to environmental economists or scientists, but also requires contribution from economists and financial economists.

3.4. Citation analysis

Papers on green finance are generally well cited. The average number of citations for the sample composed of 381 papers is 8.54. The highest citation number is 183 on Heinkel et al. (2001). Table 3 reports the top ten most cited papers in our sample. These ten papers come from very widely ranged sources, which indicates once again the interdisciplinary nature of this subject.

We also investigate the source of references cited by these 381 papers. It is plotted in Fig. 4. Clearly it is dominated by science, climate change and environmental journals. Though a few economics journals (for example, American Economic Review, Ecological Economics) are shown to affect these researches, it is obvious that finance journals are hardly involved. Citation analysis for cited journals also indicates how the relevant literature network is developed. Once again, although this area bears the name of green

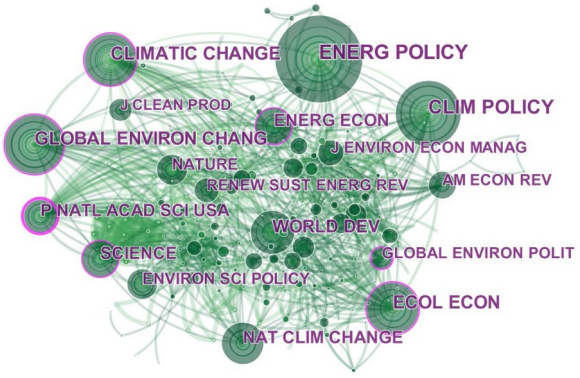

Fig. 4. Citation analysis from reference lists.

finance, its current studies are rarely based on main stream finance journals. It also indicates a clear need to introduce techniques and models in main stream finance research to study green finance issues.

4. Conclusion

This paper utilizes a simple bibliometric approach to analyze the current status and trend of development of academic research on the subject of green finance. Through ranking analysis and visualized illustration on a number of key factors of a sample of 381 relevant publications, we find important information that can help us form an accurate picture of this subject matter. Based on keywords analysis of the literature, green finance needs to be considered an interdisciplinary research topic that encompasses and deals with policies, investment and governance on financing and investment in climate adaption. As the authors' country of origin analysis reveals, green finance researches are currently dominated by scholars from developed economies. Papers in this area are mainly published by policy journals or journals focusing on environmental/climate changes, while scarcely seen in mainstream economics or finance journals.

Green finance has shown its great importance and fast growing relevance. With increasing interests in recent literature but a lack of attention from mainstream economics and finance journals, it has created a gap that gives opportunities to researchers in at least three directions for future developments. First, given that green finance is essentially a matter of finance, there is urgent need to study green finance issues from finance perspectives and using techniques from finance. Topics such as green bonds, green risk management and green governance should be of interests in mainstream finance journals. Second, more studies on green finance issues from developing countries' perspectives would be useful to regulators and policy makers to align different policy goals and develop well-defined policy objectives. With clear information advantages, scholars from developing countries will be given more chances, and more international collaboration between developing and developed countries are expected. Third, it is worth mentioning that a remarkable difference between green finance and standard finance topics is that the former is essentially policy driven. New issues in this field are thus likely to emerge with the rapidly changing international economic and political environments. Moreover, to our best knowledge, a comprehensive review of relevant literature is still not available. It is definitely worth to explore and make comparison to the results of our bibliometric analysis.

Acknowledgments

This research is financially supported by National Natural Science Foundation of China under grant no. 71573214 and the 111 Project under grant no. B16040.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.frl.2019.02.003.

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